



Air Force Research Laboratory

Materials & Manufacturing Directorate

Wright-Patterson Air Force Base • Dayton, Ohio

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ML Demonstrates Remote Controlled Aerial Vehicle for Pesticide Application



The Remotely Controlled Aerial Vehicle for Application of Pesticides (RCAVAP)

The Air Force Research Laboratory recently exhibited an unmanned aerial vehicle for pesticide application. AFRL's Materials and Manufacturing Directorate's (ML) Airbase Technologies Division demonstrated the Remotely Controlled Aerial Vehicle for Application of Pesticides (RCAVAP) at the Force Protection Equipment Demonstration (FPED) at Quantico Marine Corps Base, Virginia.

The RCAVAP is an unmanned helicopter that sprays pesticide aerially in order to moderate diseases, like malaria, that may be carried by insects in areas that are hostile or difficult to access. This spray platform should fill the niche between ground applications and larger manned platforms, such as the Air Force Spray Flight's C-130, which potentially places personnel in high-risk situations.

The RCAVAP provides a smaller platform that is easier to maintain and allows for a rapid set-up and more effective spraying of infected areas. It also allows for areas to be treated without placing personnel in harmful situations.

Historically, during wartime, disease has been said to cause more deaths than bullets. For example, during the

Mexican-American war, deaths among American soldiers caused by disease by far outnumbered any other cause. Over 1000 soldiers were killed in action, 529 died of wounds received in battle, 362 suffered accidental death and 11,155 soldiers died from disease. Disease, mostly yellow fever, a viral illness transmitted by the bite of the aedes aegypti mosquito, claimed a toll seven times greater than that of Mexican weapons.

Wartime disease continues to be a problem. During World War II, malaria, which is spread by the bite of the female anophelene mosquito, effected thousands of American soldiers. More recently, during one two-week period, the city of Baqubah in Iraq reported 250 cases of cutaneous leishmaniasis, a disfiguring parasitic disease spread by the bite of a female sandfly.

The C-130, the current pesticide platform, is more expensive, more difficult to maintain, and its large size poses a problem for today's warfighters because they often deploy as a small force. The RCAVAP can fit into these smaller areas before they have been checked for landmines, and clear the

area of harmful insects before troops even enter – avoiding risk to human life.

At the Force Protection Equipment Demonstration, the RCAVAP performed two demonstration flights consisting of automatic take-off, waypoint navigated flight, automatic payload delivery, and automatic landing. The flight path was between 0-100 feet altitude and in an area of approximately 1000 square feet.

The demonstration is sponsored by the Department of Defense, the Joint Staff, the Department of Energy, the National Institute of Justice, and the Technical Support Working Group, in order to demonstrate available equipment that will provide protection against terrorist forces and conditions that may cause harm to US personnel.

The demonstration, conducted by members of the Airbase Technologies Division's Robotics Research Group, informed government organizations about the existence of the system and the possibilities of using the RCAVAP for management of pests as well as other applications. The vehicle will provide an opportunity for technology transfer, and a prototype system will be delivered to 757th Aerial Spray Flight, the Department of Defense's only full-time aerial spray operation, in Youngstown, Ohio, for user assessment.

The RCAVAP prototype was developed by AFRL under a Force Protection Battlelab initiative, in coordination with the Armed Forces Pest Management Board, the Naval Disease Vector Ecology Control Center, and the 757th Aerial Spray Flight.

For more information, contact the Materials and Manufacturing Directorate's Technical Information and Support Center at techinfo@afrl.af.mil or (937) 255-6469. Refer to item 05-207.

ML Makes Break-Through in High Speed Machining of Titanium

The Air Force Research Laboratory's Materials and Manufacturing Directorate's Manufacturing Technology Division entered into a Small Business Innovation Research (SBIR) agreement that resulted in a 30 percent reduction in titanium machining time.

The use of high speed machining reduces machining cycle time by 30 percent, reduces unit cost for the customer without reducing profitability, and reduces manufacturing risk by understanding the cutting process at the micro level.

The use of titanium and its alloys in aircraft manufacturing has continued to increase over time due to its high strength and low weight. Uses for titanium include discs, blades, shafts, and casings for jet engines because it can operate at temperatures of sub-zero to 600 degrees Celsius. Structural

engineers specify that titanium alloys be used on airframes in several capacities, as small as fasteners that weigh a few grams to large wing beams that weigh up to one ton.

Using Third Wave System's AdvantEdge finite element machining model, researchers began to find ways to accomplish the ManTech goal of cycle time reduction. AdvantEdge analyzes machining processes, such as the milling, drilling and turning processes, in order to improve the machining rates and tool performance. The software predicts cutting forces and temperatures in the tool as well as in the workpiece. The results are then used to optimize the cutting conditions.

During Phase I of the SBIR research, the software demonstrated the possibility of reducing costs and improving the rate of productivity. In Phase II, applying AdvantEdge and high speed machining technologies

allowed for the reduction of machining time by 30 percent.

After Phase II, a Phase II Enhancement was granted to continue this research. During this enhancement, researchers enhanced the technology of the modeling and software in order to make it useful for computer numeric control programmers. As a result of this enhancement, Third Wave Systems has entered into another SBIR with ManTech that will apply the technology to additional engine components with complicated design features. The model is also now being used by the Navy and the Department of Energy in order to achieve cycle time reductions.

For more information, contact the Materials and Manufacturing Directorate's Technical Information and Support Center at techinfo@afrl.af.mil or (937) 255-6469. Refer to item 05-202.

Scientists Examine Space Stations Materials Experiments

Scientists and engineers from the Air Force Research Laboratory (AFRL), National Aeronautics and Space Administration (NASA), academia, and industry are analyzing the effects of the space environment on more than 800 experimental materials specimens that have been orbiting the Earth for nearly four years, attached to the outside of the International Space Station.

The specimens were secured in two suitcase-like containers called "Passive Experiment Carriers" (PECs), which remained in the fully opened and folded back configuration for the duration to provide exposure to solar radiation and other key environmental factors. The exposure time was planned for one year but extended due to setbacks in the space shuttle program. Both containers were returned to Earth August 9, on space shuttle Discovery. Two additional PECs are slated for launch on a future shuttle flight. The combined effort is called MISSE (Materials on the International Space Station Experiment) and was conceptualized by innovative researchers at AFRL's Materials and Manufacturing Directorate (ML) nearly a decade ago. Some of the specimens contained in the four PECs were prepared for space testing with the help of elementary school, middle school

and high school students from the Dayton, Ohio area.

MISSE is comprised of four PECs containing a total of more than 1,700 materials specimens. The first two PECs, containing more than 800 specimens, were placed into orbit in August 2001, and attached to the outside of the International Space Station (ISS). They were retrieved and returned to Earth after an unanticipated delay in the U.S. space shuttle program, following the loss of the spacecraft Columbia. The remaining two MISSE containers will be sent up to the ISS aboard a future shuttle flight and are scheduled for retrieval after one year in orbit.

The ISS offers a remarkable opportunity to test new and existing materials for future space applications. No single piece of equipment or facility currently exists that can simultaneously expose materials specimens to all the damaging environmental effects of the space environment. However, the flight data from MISSE can be used to help develop dependable correlations with ground-based data. These correlations can be used to help reduce screening and qualification costs for future spacecraft materials candidates. Due to the limited number of qualified space materials, manufacturers tend to build spacecraft

using existing, qualified materials. MISSE provides an effective means of testing new materials and re-qualifying existing materials whose raw material supplier or processing technique has changed.

Some of the materials specimens contained in the four MISSE PECs were prepared by students from the Dayton, Ohio area, as part of an AFRL/ML educational outreach program. Eleven student experiments were included in PECs 1 and 2, and 10 student experiments are incorporated into PECs 3 and 4. The students represented grades 1-11, and were challenged to identify a problem associated with long duration flight, propose a solution, and design a passive experiment to help find a solution. These tests include migration of contamination of materials in a micro-gravity environment, degradation of materials, adhesives testing, radiation shielding, and the effect of space on viral protein and non-pathogenic bacteria.

For more information, contact the Materials and Manufacturing Directorate's Technical Information and Support Center at techinfo@afrl.af.mil or (937) 255-6469. Refer to item 05-289.

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AFRL Developing an Integrated Oxygen Sensor for Aircraft

The Air Force Research Laboratory's Materials and Manufacturing and Propulsion Directorates are working on a multi-contract Small Business Innovation Research (SBIR) project to develop a sensor capable of measuring oxygen concentration in the vapor space of a fuel tank.

A sensor capable of measuring oxygen content of the vapor space above the fuel (the ullage), is critical for improving flight safety and for controlling, monitoring, and maximizing the efficiency of a fuel tank inerting system, such as an On-Board Inert Gas Generation System. AFRL researchers are developing such a sensor.

On July 17, 1996, at 8:31 pm, Trans World Airlines Flight 800, out-bound from New York, exploded and crashed over the Atlantic Ocean. Lengthy investigations by the Federal Aviation Administration (FAA) revealed that the center wing fuel tank caught fire, creating enough pressure to cause it to explode. The explosion of the jet was initiated by the presence of a combustible mixture in the center wing fuel tank.

As a result of the TWA Flight 800 tragedy, as well as other incidents, it became apparent that something needed to be done to reduce the risks of explosions caused by fuel tank fires. A concept called "fuel tank inerting" was introduced to help. This concept involves diluting ullage with an inert gas to the point where it is no longer flammable. An On Board Inert Gas Generation System, as mentioned above, allows an aircraft to maintain its fuel tanks in an inert status indefinitely. This type of system pumps bleed air, from an aircraft engine, into air separation canisters. In the canisters, oxygen is filtered from the air, leaving a nitrogen enriched mixture. This mixture is then pumped into the fuel tanks to dilute the ullage. When the oxygen level in the fuel tank is reduced to between 9 to 12

percent, even if there is a spark, the ullage wouldn't have adequate oxygen to burn.

Although this type of development is immensely helpful, it is not a perfect system. A sensor is still needed to monitor the amount of oxygen in the tank. Currently, the oxygen can be indirectly controlled by knowing the tank ullage volume, temperature and pressure, and then calculating the amount of nitrogen needed to dilute the ullage below the flammability threshold. The Air Force Research Laboratory's Materials and Manufacturing and Propulsion Directorates, in conjunction with the C-17 System Group, have initiated several SBIR programs, in the hopes of developing a sensor that can be used to directly monitor the oxygen content in the fuel tank.

The Air Force supported multiple contracts for this effort due to the variety of technical approaches. Presently, it is not known which approach will ultimately prove to be the best for aircraft use in terms of cost, weight, ruggedness, low maintenance and other considerations. During Phase I, the Materials and Manufacturing Directorate's Fluids and Lubricants Group directed the technical efforts of Tau Theta Instruments LLC (formerly PhotoSense LLC), InterSpace Inc., Aviation Safety Facilitators and Physical Sciences Inc.

Throughout the Phase I contracts, the contractors were provided guidance by an interdisciplinary team of government engineers from the C-17 System Group, Aeronautical Systems Center's Engineering home office, the Air Force Research Laboratory's Propulsion Directorate and the Materials and Manufacturing Directorate. These experts from various backgrounds have worked together in all phases of the effort, from proposal evaluation to attendance at various status meetings, providing input

from different relevant viewpoints.

Three of the companies received Phase II SBIR contracts: Tau Theta Instruments LLC, InterSpace Inc. and Physical Sciences Inc. Aviation Safety Facilitators is continuing their research in tandem. A fifth company, Advanced Projects Research Inc., who completed their Phase I with NASA, received a Congressional Add contract that will be administered by the Propulsion Directorate's Combustion Branch, for their continued efforts in the program.

For Phase II, Tau Theta Instruments LLC will continue their development of a ruggedized luminescent oxygen sensor compatible with aircraft fuel tanks and other harsh and flammable environments. The microprocessor-based sensor additionally monitors environment variables, such as pressure and temperature, and can perform system control functions through digital and analog interfaces.

InterSpace Inc. will build on its successful Phase I oxygen sensor to develop a rugged field sensor that is intrinsically safe to operate in the harsh fuel tank environment. The sensor does not require consumables or vulnerable membranes and does not react chemically with the fuel-air environment.

Physical Sciences Inc. (PSI) will continue their development of a sensor based on near-infrared Tunable Diode Laser Absorption Spectroscopy (TDLAS) technology. With this optical technology, only passive materials contact the fuel. The technology is an adaptation of PSI's low-cost, turnkey, reliable and robust single board TDLAS platform produced commercially for municipal gas pipeline leak inspection.

With their Congressional Add contract, Advanced Projects Research, Inc. (APRI) is continuing their work to develop a diode (continued on page 4)



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laser-based sensor to provide real-time monitoring of oxygen concentration. APRI's method for making oxygen concentration measurements allows for temperature insensitive measurement of oxygen concentration over a wide range of pressures with self-compensating capabilities.

Aviation Safety Facilitators continue their work on a safe Fiber Optic Oxygen measuring system that has no electrical or moving parts at the measurement site nor does it require a sample to be drawn from the point of measurement.

During Phase II, close ties with industry will be developed, allowing for the future demonstration and testing of successful approaches that could lead to the transition of the technology into military and commercial aircraft.

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The USAF Materials Technology Highlights is published quarterly to provide information on materials research and development activities by Air Force Research Laboratory's Materials & Manufacturing Directorate. For more information on subjects covered in "Highlights" or to be added to the "Highlights" mailing list, contact the Materials & Manufacturing Directorate Technology Information and Support Center at (937) 255-6469 or e-mail at techinfo@afrl.af.mil. Approved for Public Release (AFRL/WS#05-2789).

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